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THE LOST ARTS OF CHEMISTRY[1]

IN addition to chronicling past and present events merely, it pleases the historian from time to time to ascertain, as nearly as he can, by a comparison of present with past conditions and present knowledge and practise with past knowledge and practise, the present condition of mankind of any particular society, in comparison with past conditions. Thus are compared present systems of government with past systems, new religious beliefs with old, modern science with ancient science, present-day arts and manufactures with those of old.

Progress never takes a straight course for any considerable length of time. Nor does it even follow an undulating course in one general direction. But there are advancements and retrogressions, repeated endlessly. And again progress as recorded by history does not represent necessarily the progress of the whole human race. On the contrary, it does not represent even a large part of the human race, but at most an isolated portion of it, and in this isolated portion the progress is recorded not of the whole but of the most advanced individuals only. When we say that the present age is one of great business, scientific and manufacturing or artistic achievements in comparison with the fourteenth century, for example, we mean that a few individuals, very few in fact compared with the total number, have contrived to bring about great results in those fields of human activity. But we must remember at the same time that the majority of indi-

[1] An address delivered before the Minneapolis meeting of the American Chemical Society, December 28, 1910.

viduals may not have been directly concerned in the advance or may not have contributed directly to it at all. Indeed, it seems as though the lowest members of the human race to-day are no farther advanced mentally than were their progenitors in recent geologic times. Even with rapid progress of the most favored or most enterprising individuals there may be little progress or none in the case of the average of mankind. It is not unlikely that at the present day the intellectual gap between the mentally highest and lowest of mankind is greater than at any previous time.

In spite of the high intellectual and practical standard reached by the leading men of to-day, from another point of view (called by some the pessimistic) the outlook to-day is far from satisfactory in politics, religion, manufacture or science. Whether we consider our all but failing efforts at democracy in the United States or the vacillating and undirected religious tendencies of the people (as shown by mormonism, seventh day adventism, dowieism, christian science, the old theologies or the strange oriental doctrines and ideals of the majority of our people, which fortunately are scarcely put into practise); or if we consider the slow conservatism and plodding course of manufacture and business, including our great untouched problem of the economic distribution of goods, we can not fail to be impressed with the length of the journey which we must sooner or later take, on the road of development.

But we may turn from the rather unsatisfactory consideration of politics, religion and business to the consideration of modern science with a rare degree of satisfaction and enthusiasm. There, at least, progress is visible, tangible or even obtrusive. There, at least, the forward movement does not take the slow, conservative, timid pace of business, nor follow the meandering, uncertain, sentimental path of religion, or the crude meaningless way of politics. In that field at least the way is certain, the methods positive, the results satisfying, the application secure and the progress lively. Considered by itself, science and the scientific method are the most satisfactory and satisfying things in the possession of the human mind. The unfortunate thing—it can not be classed as a criticism—about science is that it has left the multitude untouched. With the results of science and the scientific method on every hand forming so large a part of our splendid materialistic civilization, nevertheless the great, the overwhelming majority of people are ignorant of the methods, the aims and the results of scientific inquiry in daily use, and of daily necessity. Of even greater import, the scientific method of thought is not a part of their mental equipment.

Science and the scientific method have their critics, no less than other excellent things. Science is unmoral, cold, heartless, pessimistic, hopeless, often cruel in method, say they. The scientific inquirer can well afford to let most of such accusations as these go unchallenged. But there is one statement which has been sown broadcast, which springs up in a thousand unexpected places, and which it is worth while to devote some attention to in order to refute it. It is the statement that ancient peoples have been possessed of knowledge and of arts unknown to modern times; and indeed people would have us believe that this knowledge and these arts are recoverable by us if at all only with extreme difficulty. The "lost arts" is the cry. In so far as these so-called lost arts concern applied chemistry let us examine into them, and ascertain if posible whether or not there is truth in the assertions alluded to.

In the first place we may well inquire into the origin of the wide-spread belief that the knowledge of various mechanical and chemical arts has been lost to mankind. Probably first among the causes is that universal veneration of antiquity which makes gods and saints out of heroes and martyrs of the past, leads to ancestor worship and in general exaggerates the virtues, the crafts and the deeds of valor of olden times. Secondly, the delight of many persons in mystery, their tendency toward belief in the mysterious, occult and miraculous, against their better judgment and the facts in the case, have great influence in originating and perpetuating the belief in lost arts. Thirdly, among the more general causes, we may place vague statements or sentences which we can not accurately translate in ancient manuscripts. Fourthly, the natural reaction against an egotistical age. Fifthly, the use by ancient peoples for certain purposes of materials which we would not use to-day on account of their unsuitability. This leads to the conclusion that the ancients knew of different and better methods of preparing the material. Sixth, it has pleased certain writers and lecturers to insist strongly upon the point that there have been at various times in existence arts no longer known and used. One finds brief statements in various books of such import as "they knew how to harden copper." "Their mortar outlasted the stone it cemented." "The degree of perfection they reached in enameling has never since been attained," etc. In America the man who has had probably more effect than others in this respect was Wendell Phillips. His lecture entitled "The Lost Arts" was first delivered in the American lyceum course in the winter of 1838. During succeeding years the lecture was repeated about two thousand times and was heard by all sorts of audiences throughout the country and at the time and subsequently made a great impression. Many persons now living still remember the famous lecture. It is difficult to read this lecture to-day and believe that it was seriously intended in certain places by Wendell Phillips; yet I am assured by several individuals who heard it that, although illumined by humor in places, it was, as a whole, seriously intended and received. In various lectures Phillips committed many sins against accuracy and truth, but in none more than in the "Lost Arts." He misquoted Pliny in regard to his statements about the origin of glass manufacture—a tale familiar to you all and hardly rising to the dignity of a first-class fable. And of all authors, Pliny can least afford to be misquoted, being already overburdened with inaccuracy and unreliability. Let me present a few brief quotations from this remarkable lecture.

> The chemistry of the most ancient period had reached a point which we have never even approached, and which we in vain struggle to reach to-day. Indeed, the whole management of the effect of light on glass is still a matter of profound study.
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> The second story of half a dozen—certainly five—related to the age of Tiberius, the time of Saint Paul, and tells of a Roman who had been banished, and who returned to Rome, bringing a wonderful cup. This cup he dashed upon the marble pavement, and it was crushed, not broken, by the fall. It was dented some, and with a hammer he easily brought it into shape again. It was brilliant, transparent, but not brittle. I had a wineglass when I made this talk in New Haven; and among the audience was the owner, Professor Silliman. He was kind enough to come to the platform when I had ended, and say that he was familiar with most of my facts; but speaking of malleable glass, he had this to say—that it was nearly a natural impossibility, and that no amount of evidence which could be brought would make him credit it. Well, the Romans got their chemistry from the Arabians; they brought it into Spain eight centuries ago, and in their books of that age they claim that they got from the

Arabians malleable glass. There is a kind of glass spoken of there that, if supported by one end, by its own weight in twenty hours would dwindle down to a fine line, and that you could curve it around your wrist.

Cicero said that he had seen the entire "Iliad," which is a poem as large as the New Testament, written on a skin so that it could be rolled up in the compass of a nut-shell. Now, this is imperceptible to the ordinary eye. You have seen the Declaration of Independence in the compass of a quarter of a dollar, written with glasses. I have to-day a paper at home, as long as half my hand, on which was photographed the whole contents of a London newspaper. It was put under a dove's wing and sent into Paris, where they enlarged it and read the news. This copy of the "Iliad" must have been made by some such process.

Pliny says that Nero the tyrant had a ring with a gem in it, which he looked through, and watched the sword play of the gladiators—men who killed each other to amuse the people—more clearly than with the naked eye. So Nero had an opera-glass.

So Mauritius the Sicilian stood on the promontory of his island and could sweep over the entire sea to the coast of Africa with his nauscopite, which is a word derived from two Greek words, meaning "to see a ship." Evidently Mauritius, who was a pirate, had a marine telescope.

The French who went to Egypt with Napoleon said that all the colors were perfect except the greenish-white, which is the hardest for us. They had no difficulty with the Tyrian blue. The burned city of Pompeii was a city of stucco. All the houses are stucco outside, and it is stained with Tyrian blue, the royal color of antiquity.

But you never can rely on the name of a color after a thousand years. So the Tyrian blue is almost a red—about the color of these curtains. This is a city all of red. It had been buried seventeen hundred years; and if you take a shovel now, and clear away the ashes, this color flames up upon you, a great deal richer than anything we can produce.

I feel reasonably sure from what I know of the history of science that the main points made in this lecture were not true in Wendell Phillips's time. I know they are not true to-day.

To recapitulate: the causes of a belief in lost arts appear to be the veneration of antiquity, the belief in the mysterious and occult, inaccuracies in and inaccurate readings of ancient texts, reaction against present-day egotism, the use of unsuitable materials by ancient peoples and the emphasis laid upon ancient skill by half accurate writers.

No one could wish to detract from the great, the skilful and the beautiful works of the ancients. All we can desire is a proper and clear understanding of their accomplishments.

Long before the way was prepared for an approach to chemistry as a science, many were the chemical facts known and used and many the chemical arts and manufactures which arose and flourished. The foundations of many of our greatest chemical industries were securely laid long before the science of chemistry lent its aid. The industries of cement and plaster, glass, ceramics, pigments, oils and fats, varnishes and lacquers, sugar, fermentation, textiles, paper, dyeing, leather, glue and various metallurgical industries are some of those which were very well developed before the advent of scientific chemistry. Indeed, the science of chemistry has found and still finds some of its richest materials in these very industries. What can be accomplished by patient manual skill and dexterity is amazing, and it must be conceded that the adoption of exact mechanical processes in our times has lessened the necessity for such skill in many directions. It is true also that many ancient peoples and many of the less mechanical modern ones have applied manual dexterity to their arts in such a way that we marvel at the results. But it is difficult to find a case where similar application to-day would not yield a similar result. Nothing can be considered lost unless it be the demand for and desire to produce works of a certain kind.

Again it is true that some arts and

modes of manufacture reach a stage which we may call practical perfection, relatively soon after the initial discoveries are made which give them their first impetus. After this point is reached the improvements are few or none (and if any occur, they come from an outside source, as the application of power to the loom). Examples are abundant: the hoe and other simple farming implements; the safety bicycle; the sewing machine; the aeroplane. It must, of course, be presupposed that suitable materials for manufacture have been previously discovered and are at hand, or can be quickly adapted. In such cases as these the opportunities of later generations to develop and improve are meager; but the limitation is not of the inventors, but of the things themselves.

For many years the great pyramid of Egypt was held up to the youth in all lands as an example of what had been accomplished by ancient peoples and which could not be duplicated to-day. It was held in fact that the ancient Egyptians were possessed of mechanical knowledge and appliances unknown to us. We must all concede that the great pyramid is a remarkable, if useless, piece of architecture, laid out with extreme precision and carried to its completion in a masterly way. But it turns out that the Egyptians of the Old Kingdom possessed rather limited knowledge of mechanics, not having even developed the movable pulley. The great pyramid was built by man-power multiplied many thousand times. Finally, can it be considered a greater work than a great railway system or battleship?

That arts have been temporarily lost at least for practical purposes is true. The history of industry has not yet been written—possibly it is too great a task—and adequate data have not been collected and hence are not available, but it seems true from the information available that there has been a remarkable continuity in industrial processes in spite of many adverse circumstances.

War is probably the greatest cause of breaks in the continuity of manufacturing processes and the arts of peace, and if we are to believe past records, the domination of theological systems or religious dogmatism has been and is the most effective influence in restraining the development of scientific methods of inquiry and consequently progress in the arts. On the other hand, commerce and the migrations of peoples have been effective in spreading industries. War destroys commerce, but often causes migrations, and hence has been an active influence in the spreading of industry as well as in checking it. War has also imposed new civilizations on old, and thus caused an unnatural intercourse between two civilizations, which would naturally result in the extension of knowledge of the industries peculiar to each.

Let us examine for a few moments some of the arts claimed to be now lost. The knowledge of a process for hardening copper is commonly ascribed to many ancient and prehistoric peoples and is devoutly believed in by many persons. Now in the first place if this knowledge was formerly possessed we have no direct evidence of it, for the copper implements which have come down to us are no harder than those we might make ourselves to-day. A metal may be hardened in two ways: by physical treatment or by alloying it with other metals or substances. Copper may be hardened to some extent by hammering, in the same way that many other metals may be hardened. The common alloys, bronze and brass, are harder than the pure metal. It is probable that ancient peoples used the process of hammering to harden copper and it is certain that they made use of the

alloys of copper first with tin and later with zinc, for many purposes, including tools and implements. But because copper and copper alloys were used for implements subjected to rough usage, this does not justify us in concluding that the makers had knowledge of a method for making the metal hard, durable and serviceable. The simple and direct explanation is that they had no better material for the purpose at their command, just as in the bone and stone periods bone and stone were the best materials of construction available for tools and implements. There is no justification for the idea that ancient peoples knew how to harden copper by means unknown to metallurgists of the present day.

The ceramic arts are among the oldest known to mankind and the earliest development of them will probably remain unknown to us. They had their beginnings in the bone and stone age, and were probably first practised by women, not by men. The first clay vessels may have been clay-covered baskets dried in the sun—we do not know certainly. From those early beginnings to the highest types of the art required the labor of many potters, numberless experiments and numberless failures. We class ceramics among the chemical industries, and properly so; and yet the ceramic art originated, developed and flourished in many ages and in many parts of the earth without any thought of or aid from the science of chemistry. It has always been and still is to a very large extent an empirical industry. The essential difference between the pottery practise of ancient times and the most scientific practise of modern times lies in the reproducibility of bodies and glazes by modern methods. And yet few chemists in the industry have the temerity to predict how a new clay or glaze will come out of the kiln. The potters of long ago, by countless trials of different materials and countless failures, were able to produce certain effects; and they were able to continue the manufacture of similar wares and produce similar effects so long as they were able to obtain materials from the same sources. A change of material would almost certainly mean a change in product. It must not be forgotten that this same limitation affects the ceramic industry to-day to a very large extent. The varieties and properties of clays are almost numberless. It is true that potters of all times have been able to devise certain simple tests whereby they have been able to recognize differences and similarities in their raw materials, but these tests were usually of too crude a character to make refined distinctions. Now from the very fact that ancient potters were dependent on certain sources of supply for materials to produce certain wares, it was very natural that wares made by a certain people at a certain time were not made by that people at another period, or by different peoples. And such a case would probably be classified as a lost art. But this can not properly be called a lost art. Rather it is a case of lost materials! Given the materials, the wares could be made as at first. This in fact has been the work of more recent times—to ascertain by careful analysis the nature of various bodies and glazes and reproduce them. Of course the composition is not the whole secret, the heat treatment is almost equally important, and this is a matter for careful physical testing. But as the result of modern research and practical experiment it can scarcely be maintained that any body or glaze exists which has not been and can not be reproduced.

Glass manufacture is allied to the ceramic industry, and is probably the outgrowth of it. In spite of Pliny's fable to

account for the origin of glass making, it is altogether likely that glazes and enamels were the immediate forerunners of glass. Glass manufacture had its origin in Egypt, not far from 2500 B.C. Who shall say that the natural mineral resources of the country (among them limestone, sand and alkalis) were not responsible for its origin there? It spread to the countries east and north of Egypt to Greece and Rome, to Spain, France and more recently to Saxony, Bohemia and Austria—finally over the civilized world. At the present time the data for a history of glass manufacture are probably as complete and available as that for any other of the chemical industries—and possibly more so. The ancient glasses were usually not perfectly transparent but were translucent, in some cases nearly opaque. Transparent glass and particularly transparent glass in large sheets, is a modern production. Many of the ancient glasses and those of early modern times possessed great beauty, considered from the standpoint of the fine arts, although their utility as light transmitters is low. In Greece and Rome glass was used for plates and saucers and other table ware, for pitchers and ornamental objects, as tile in pavements and walls, but scarcely at all in windows. With the advent of transparent glass the production of the translucent varieties did not expand, until finally the art languished in many countries and has but recently been revived for many decorative purposes. It should be noted that the art was never really lost, but the interest in and demand for translucent, tinted and rough-surfaced glass was low.

The dyeing industry is another which dates from the remotest antiquity and which was developed without the aid of scientific chemistry, on an empirical groundwork. However, ancient colors, largely derived from vegetable sources, were reproducible. The use of mordants was practised by many ancient peoples, particularly by the ancient Egyptians, who used them not only for fixing colors, but for producing different shades from the same dye bath. With increasing commerce between nations, new sources of dyes became available and the vegetable-dyeing practise had reached a high degree of perfection when the coal-tar dyes were brought forth in the chemical laboratory to the wonderment of mankind and the revolutionizing of the industry. It has never been claimed, I believe, that the art of dyeing with vegetable colors has been lost or not practised. But there is a strong tendency at the present time to disparage the aniline colors. It is very commonly said and accepted as true that vegetable dyes are superior to coal-tar dyes. That vegetable dyes are fast and coal-tar dyes are not. Persia has recently prohibited the exportation of rugs and fabrics dyed with anything but vegetable dyes, ostensibly to maintain her reputation in the rug industry. Who shall come forward and refute these charges, which are of course all but groundless? There are good and bad dyes, both coal tar and vegetable, and the best dyes must be skilfully used to produce good results. Let us hope that the coal-tar dyes will be increasingly appreciated, and that the time will not come when people will lament the lost art of vegetable dyeing!

But what about the cement and plaster of the ancients which outlasted the ages and even the stones which it held together? In the first place any cement or plaster which was not remarkably durable could not possibly have been preserved to this day. The ancients in various countries and at various times have been well acquainted with lime, burned clay-limestone (hydraulic lime), hydraulic cement, vari-

ous natural cements, puzzolan, and plaster. Would it not be strange if among the materials used some would not be found to yield a cement of unusual strength? And if the setting process continued through the ages and conditions were such that weathering did not seriously attack it, the final product yielded would certainly be extremely hard. But in any case it is certain that the weaker cements have not come down to us but have been disintegrated long ago. The cement which is being made in enormous quantity to-day under scientific control will probably outlast any similar material which the world has seen.

But we may go a step farther in our inquiry after relegating the "lost arts" to the same mythological museum which holds the lost Atlantis. Not only is it unlikely that there are any "lost" chemical arts, but it is highly probable that ancient peoples were ignorant of many arts attributed to them, and which are well known at the present day. Such a misunderstanding could probably best be dispelled by a carefully compiled history of arts and manufactures, particularly ancient arts and manufactures. The production of such a book is a consummation devoutly to be wished.

I have an idea that it is not a difficult matter to gain a mental picture of conditions in ancient workshops. I believe that the mental attitude of artisans has not changed much during the lapse of hundreds or even thousands of years. Go into any small shop at the present day where a specialized art or craft is practised and I fancy that you will find the workers there in all essential respects, so far as their craft is concerned, like the craftsmen of distant ages. You will find there the same lack of organized knowledge, the same sort of unnecessarily detailed and elaborated empirical knowledge, the same narrow conservatism and adherence to formulæ and rule-of-thumb methods. If you talk to the men you may learn how they learned their craft; of the most skilful members of the craft they have known; if you gain their confidence they may tell you of their past experiments (most of them foredoomed to failure) and of future experiments planned, when time permits or when they obtain material possessed of certain hypothetical properties. And you will be impressed by the way results are sometimes accomplished in spite of the use of the clumsiest mental and physical methods of experiment imaginable. A typical craftsman will experiment with all the materials he can lay hands on without the slightest scientific consideration of the case, in an effort to produce a certain result. These things are interesting and we must hope they will never be altogether lost. But our ideal for the present and the future must be a large and adequately organized industry, resting firmly on engineering skill and chemical investigation, operating with a full understanding of all its processes and with assurances of consistent and logical future development and expansion.

W. D. RICHARDSON

THE ELIZABETH THOMPSON SCIENCE FUND

THE thirty-sixth meeting of the board of trustees was held in Boston, Mass., on February 10, 1911.

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